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State-of-the-Art FUE: Advanced Non-Shaven Technique

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Follicular unit extraction (FUE) has grown in popularity at an exponential rate for a variety of reasons. Patient demand is a key reason. The most significant disadvantage of FUE as it was originally offered, and later modified, is the necessity to shave all or portions of one's head. For this reason, I developed the non-shaven FUE (NSFUE) technique in 2003. I introduced this method of FUE to Korea in 2008 where colleagues Drs. Jisung Bang and Jae Hyun Park have successfully incorporated it into their practices.

A modification of FUE involved leaving the hair longer above and below a shaved area. Depending on the length of the surrounding hair, you could shave one large patch under longer hair (greater than 6cm in length) or multiple smaller patches under shorter hair (less than 5cm). Shaved patches within longer hair allow removal of several thousand grafts without shaving the entire head (Figure 1). Shaved patches within shorter hair limit the number of grafts obtainable in a single sitting (Figure 2).

Figure 1. Long hair allows for a shaved patch equal to the entire safe donor area. A wide shaved area allows a wide, irregular distribution of FUE extraction sites or a more homogenous distribution of FUE harvest sites.

A disadvantage of shaven patches is the difficulty concealing this unnatural haircut. If the surrounding hair is quite long, the shaved area can be concealed easily. However, if the hair is somewhat shorter, there is a greater risk that the hairstyle will be discovered. More importantly, harvesting from multiple, small shaved patches leaves high density above and below the harvested area(s), which can lead to patient dissatisfaction with donor area appearance (Figure 3A and B).

Figure 2. Shaved patch will invariably result in fewer grafts and an unnatural appearing cluster of hypopigmented scars in a narrow band within the safe donor areas. *(Photo courtesy of Dr. Jae Hyun Park.)*

I discovered the problem with shaven patches the difficult but common way mistakes are discovered. After treating a strip scar with the NSFUE method in 2003, the patient complained that the concentrated cluster of FUE white dots looked worse than the strip scar. Since then, I have heard other patients complain about shaven patches both in my hands and in the hands of other physicians. I now only use the shaven patch FUE method when the surrounding hair is long enough to cover the area and the entire safe donor area is shaved since grafts may be harvested with a random distribution so that discrete patches of white dots can be avoided. In women, however, the entire safe donor area can be shaved because they typically have longer hair.

In other instances, I avoid the shaven patch; an irregular pattern of extraction sites is aesthetically superior to isolated strips of hypopigmented extraction sites.

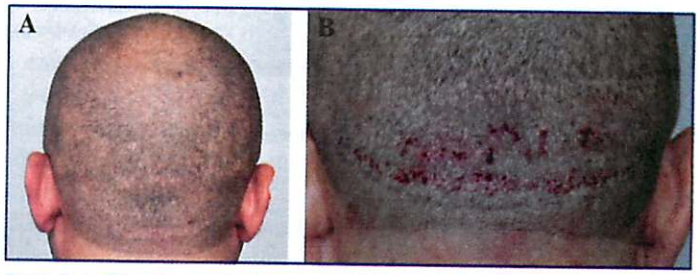

Figure 3. *A:* The strip scar has been successfully treated with FUE grafts, however, the patient now complains of the hypopigmented scars from the shaved patch. The more irregular hypopigmented scars superior to the shaved patch were acceptable to the patient. *B:* Grafts obtained by FUE in an irregular fashion from the safe donor area or the beard may be used to treat a pattern of hypopigmented scars due to shaved patches.

The Individual Follicular Cluster Trimming Technique

Once I discovered the problem with shaved patches, I looked for ways to trim donor follicular areas selectively and rapidly. My goal was to prepare approximately 25% of the hair follicles for grafting while leaving the remainder of the follicles uncut so that I could obtain an optimal graft harvest and the patient could more easily conceal the extraction area.

I tried using hair-thinning shears because thinning shears are often used to thin a male's hair during a haircut. Although these cut large areas quite well, the problem was controlling the distribution: too many hairs were cut in a small area while other areas were not cut at all. To remedy this, I tried removing some of the teeth on the thinning shears without success. I next removed some teeth from an electric razor, again without success.

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FUE Non-Shaven Technique *from front page*

I thought of using a sharp punch to cut the hair follicles of individual clusters. With this tool, you can either cut the hair and the graft in one step, or you can cut the hair first and then cut the graft in two steps with the same punch. As a third alternative, you could use a punch to first cut the hairs in the groups and then later return to cut the grafts.

An advantage of using a sharp punch is minimization of skin and follicle distortion. However, when the punch is used to cut hair, it is dulled and the most important advantage of the sharp punch is lost. Only fine hair is easily cut with a sharp punch; coarse hair requires more axial force to cut the hair, which quickly dulls the punch.

Furthermore, it is difficult to see the angle of hair emergence with the hair long. The stiff nature of the hair follicle cluster can cause the punch to slide slightly to one side so the cut is off center rather than at the center of the circle, or "bull's-eye."[1] In 2005, we tried using a mechanical punch to cut the hair and the graft simultaneously but this provided less than optimal results. More recently, Dr. Park called this technique the *direct non-shaven FUE technique*. Inevitably, a consequence of using the punch to cut the hair and the graft is a higher transection rate and grafts that are not optimal. Dr. Park noted that his average follicle transection rate more than doubled using this direct non-shaven FUE technique.

The only remaining advantage of the direct non-shaven technique is the elimination of a step in the donor area preparation phase. With the aforementioned issues, this alone is not sufficient to justify using the punch to simultaneously cut the hair and the graft.

Finally, I resorted to using scissors to trim the individual clusters of hair and the punch to cut grafts. This proved to be the most time consuming but most precise way to obtain an even distribution of prepared clusters and optimal grafts. There was less follicle transection regardless of whether the punch to cut grafts was dull or sharp, because the angle of hair emergence was easy to see. And since the hair is already cut, the punch will not slide off center.

Figure 4. Modified scissors for trimming individual follicular groups has a narrow tip. The distal point of the scissors is blunted to avoid puncturing the skin of the patient.

Eventually, I created a protocol that currently allows me to trim enough clusters to obtain over 3,000 grafts in a single sitting without shaving the head. Along the way, I modified the scissors to more easily accomplish this task (Figure 4). The donor area can be prepared for surgery in under one hour with a team approach. My team approach involves three assistants trimming the donor area simultaneously.

The Cole Isolation Technique

I begin by dividing the donor area into 14 distinct regions over the 203cm^2 safe donor area (SDA).[2] A donor template facilitates this design process. These regions include 8 larger major regions and 6 smaller minor regions (Figure 5). The minor regions lie in the more inferior surface area within the SDA. In general, I avoid these inferior regions in initial surgeries unless I am planning a very large procedure requiring grafts from this area. I avoid them because the hair is finer and there are more telogen hairs in this region. The significance of a higher telogen ratio is unknown, but hair loss in nape of the neck, *retrograde alopecia*, is quite common. A higher telogen ratio may be indicative of a higher probability of future thinning in the inferior region of the donor area. Furthermore, the extraction sites toward the nape of the neck are more commonly visible when patients elect a very short "fade" hairstyle.

Once the donor area is divided into 14 regions, trimming hair clusters begins (Figure 6). My team of three works simultaneously, one region at a time, with an inferior to superior progression while the patient is seated. One assistant sits in the occipital area, while the other two sit on the contralateral parietal-temporal aspects of the patient.

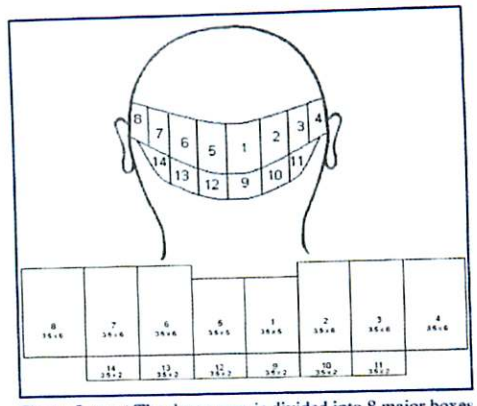

Figure 5. *(top)* The donor area is divided into 8 major boxes and 6 minor boxes within the safe donor area. *(bottom)* The boxes are numbered so that the total extractions from each box, the surface area of scarring in each box, and skin lesions in each box can be easily recorded.

Figure 6. Some follicular units are trimmed, while others are not, within the safe donor area so that the extraction sites may be concealed immediately following surgery. *(Photo courtesy of Dr. Jisung Bang.)*

Dividing the donor area into 14 regions allows me to determine how many clusters need to be trimmed in each region. If the case is small, they trim randomly throughout the major regions. If a maximal harvest is needed, they will trim every other cluster or at least 25% of the clusters within a region. The average number of follicular groups in each of the 8 major regions is 1,542; therefore, maximal trimming (25%) would consist of 386 follicular groups. In each of the 6 minor regions there is an average of 495 follicular groups. Maximal trimming consists of at least 124 follicular groups. Generally, my staff exceeds these minimums simply to ensure the target goal is met. Dr. Bang also trims slightly more than he plans to extract to ensure his graft target is reached.

For example, if 1,000 grafts are to be harvested from the 8 major regions, at least 125 clusters should be trimmed within each region. It is not uncommon to increase the number of trimmed clusters as much as 75%. All trimmed clusters are not necessarily harvested. Alternatively, I might harvest more than are initially trimmed. I do my best to avoid trimming a second time, but it is easy to trim more clusters if needed. If an area is overtrimmed, the patient is given a concealer, such as Couvre, DermMatch®, or Nanogen, to use until the hairs are grown out.

When only a few additional grafts are required from a region that has already been trimmed and harvested, I often will use the punch to first trim the hair and then cut the graft. Alternatively, I might choose the direct non-shaven approach and use the punch to cut the hair and the graft simultaneously. Invariably, this process will shorten the lifespan of a sharp punch.

When trimming hair, the chief objective is to ensure the proper length of cut hair. If it is too short, it can be difficult to see the exit angle of the hair. With tumescence, the length of the hair will appear decreased as the skin expands. The tumescence will dissipate over a brief period of time but this can delay the harvesting process. Conversely, if hair length is too long, the direction of hair growth may appear different than it actually is due to the natural curve of all hair toward the skin surface. Longer trimmed hair can make passing the punch over the follicles more difficult and time consuming. Hence, it is imperative that the length of the hair be optimized.

Patients have individual donor characteristics that impact the number of follicular groups that can be trimmed successfully.

Trimming is limited if the patient has a lower density and fine hair or if the patient has multiple scars or wide scars. When the patient has high density, coarse hair and wavy hair, maximal donor trimming is more easily concealed.

Harvesting

When harvesting, I work in a seated position. I begin at the inferior-most point of a region and work from left to right on the right side of the patient and right to left on the left side of the patient to take greatest advantage of gravitational forces on the flow of blood. Within each region, I move in small incremental steps from inferior to superior, again to take advantage of gravity. To keep the operative field clear of blood, I use vasoconstrictive tumescence and micro-suction. The suction tip often tends to move the hair into the surgical field so care must be exercised.

As I move superiorly, I use a lightweight aluminum hair clip to hold hair out of the surgical field. The weight of the clip is an important consideration; a heavier clip tends to fall down into the operative field. I also use my punch, both manual and mechanical, to sweep stray hair out of my surgical field and improve my view prior to cutting individual follicular clusters. As I move superiorly, I relocate the hair clip several rows up. When I advance to the level of the clear field, I move the clip superiorly again to expose more trimmed follicle clusters.

It is important to note that my two most medial major regions contain only 17.5cm^2, while the three lateral regions to each side each contain 21cm^2. When planning my procedure, I often have to take a few more grafts from the lateral regions to make up for the reduced size of the medial regions. Alternatively, I can harvest a higher percentage from the medial two regions (1 and 5 in Figure 5) because follicular unit density is often higher in the medial regions. Generally, I plan to harvest at least 10% of the desired graft total from each of the 8 major regions. Then I can use the inferior minor regions to harvest the remaining 20% of my desired total. The 6 minor regions are equal in size to 2 major regions.

For example, if I want to reach a target of 2,000 grafts, I need to harvest a minimum of 200 grafts from each major region and 400 grafts from the minor regions. However, if I wish to harvest precisely 2,000 grafts from the major regions, I must remove 250 grafts from each region. The total number can also be limited from the most lateral regions (4 and 8) as long as the number from the more medial regions adjusts accordingly. The density is often lower laterally to begin with and the hair is often finer. Overharvesting these lateral areas may result in patients complaining the area is too thin following maximal harvesting, especially when you maximally harvest more than one procedure. The following table can help to help plan a procedure based on the desired graft count:

Number of Grafts Harvested from Each Major Region

TARGET	GRAFT RANGE
25	200
50	400
75	600
100	800
125	1,000
150	1,200
175	1,400
200	1,600
225	1,800
250	2,000
275	2,200
300	2,400
325	2,600
350	2,800
375	3,000
400	3,200
425	3,400
450	3,600
475	3,800
500	4,000

Only dense donor areas allow more than 400 full-size follicular clusters from any major region in a single procedure. Only the most dense donor areas will yield 500 or more full-size follicular clusters.

I cut, remove, and place grafts in rapid succession to expedite the procedure and minimize the time out of body for the grafts. The seated position facilitates this process. I begin harvesting on the right side in box 3 or 4. When I am finished cutting one box, I move to the left side in box 7 or 8. As I begin harvesting in box 7 or 8, my assistant removes the grafts in the box I just cut. Generally, it takes me 3-5 minutes to cut each 100 grafts. The cutting rate is predicated by individual patient characteristics, which influence the complexities and difficulties of each case. When I finish cutting box 7 or 8, I move back to the right side to harvest another box while my assistant moves to the left side to remove those most recently circumscribed grafts.

As soon as I have the grafts out, my Registered Nurse begins local anesthesia in the recipient area that I designed prior to starting the procedure. Discomfort in the donor area is much less than in strip surgery, however, local anesthesia to the recipient area does not last as long with FUE. Once anesthesia is achieved, I make recipient sites. I move in a central to peripheral direction to avoid tachyphylaxis to the local anesthesia.

My assistant and I continue alternating side-to-side during the harvesting process, while one or two assistants place grafts in the recipient area. Once all the grafts are harvested, I add a third assistant to help place grafts if needed. My objective is to get as many hands on the patient as possible so that the procedure progresses as quickly as possible.

I use a minimal-depth approach to harvest grafts. I set punch depth typically between 2-3mm deep. I insert the punch to 2mm initially. I then insert my extraction forceps (ATOE) to the maximal depth of the incision and attempt to remove the graft by applying either external force on the graft or by pushing the donor area skin away from the graft (counter-traction) with my Castroviejo forceps (Figure 7).[3] If the graft is easily plucked from the donor area, I consider extracting at a more shallow depth.

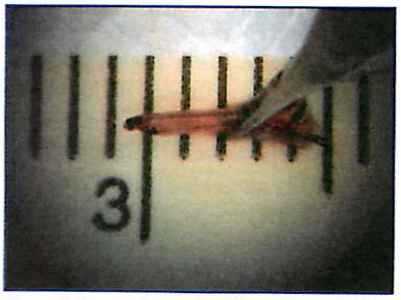

Figure 7. I insert the Aide to Extraction (ATOE) to the maximal depth of the incision, grasp the graft firmly with the ATOE forceps, and then ease the graft out. The maximal depth is typically between 2mm and 3mm. In this instance, the maximal depth was approximately 2.2mm.

The graft is eased out rather than jerked out so that the entire outer root sheath (ORS) and connective tissue sheath remain on all the hair follicles. If one or more follicles lack a portion of the ORS or the inner root sheath (IRS), the follicle has been plucked and we must either incise deeper or use a more gentle

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extraction force on the graft. You can use as much compression force on the graft with the ATOE as desired without negatively impacting hair growth.

If the graft does not pluck easily from the tissue, I incise deeper. I continue adding depth to the punch until I locate an incision depth that allows easy extraction. Once I find a depth that allows easy extraction, I see if a more shallow depth will allow easy extraction. For example, if I increase the depth to 2.5mm and find that the extraction is easy, I then change the depth to 2.2mm to see if the graft is still easily plucked intact. If 2.2mm does not work, I try 2.4mm. My objective is to always find the least depth because minimal depth reduces follicle transection, especially when there is hair splay. When I must incise deeper, hair splay often necessitates an increase in my punch size due to follicle splay.

A variety of factors influence the ease or difficulty of graft removal. One way to remember these factors is by using the mnemonic "Arcades":

A. The angle of hair emergence predominately in the x and y axis. An acute slope and a larger value for x in either the negative or positive direction increase extraction difficulty.

R. A restless patient who is constantly moving will slow and complicate the extraction process.

C. The consistency of the skin influences the life of a sharp punch. A rubbery skin dulls a punch more quickly and it can increase extraction difficulty. A soft skin allows a long life to a sharp punch. A duller punch will require more axial force, require more tangential force, slow the dissection process, increase follicle displacement in response to axial force, and increase the probability of follicle transection. The way to overcome a dulling punch is to increase the tangential force, such as the RPM. I usually start with a true 1,250 RPM and increase in increments (e.g., 1,800, 2,500, 3,000, 4,000). At some point, the transection rate increases as the punch dulls. Once the transection rate begins to climb, the punch should be changed. Obviously, the other solution is to change the punch when it begins to dull.

I would like to add that, in some instances, a much higher RPM is optimal to overcome the tensile strength of the skin and to minimize transection. This is especially true in rubbery skin. When you find that the transection rate is high even with a larger punch or a smaller punch, you should consider a very high RPM. This is one reason I created the Vortex device, which allows me to achieve higher RPM up to 25,000. Sometimes, but not always, this higher RPM is the optimal solution to a case of FUE. You will also find that there is a range of RPM where the transection rate is higher with a very sharp punch. Once you exceed this range, the transection rate will decline. In addition, at a very high RPM, the skin is cut much cleaner, whereas at a lower RPM, including the very low range, the skin seems to initially tear rather than be cut so the edges are jagged and not smooth. I would not start above 2,500 RPM with a fresh sharp punch. Both rubbery skin and soft skin may be found in elastic (loose) skin and firm skin. Each characteristic is distinct and different.

A. The attachment between the adipose and the ORS and the attachment of ORS to the IRS are important. In standardized FUE terminology, this is referred to as tethering.[3] A firm attachment between the ORS and the adipose requires a deeper incision. A weak attachment between the ORS and the IRS requires a deeper incision.

D. The depth of incision influences follicle transection. When I must incise closer to 3.0mm or rarely deeper, the rate of follicle transection tends to increase markedly. The goal is to keep follicle transection under 3% and graft transection under 12%. Minimal depth reduces transection rates and also improves follicle regeneration with ACell.

E. The elasticity of the skin influences follicle movement in response to an axial force. Firm skin tolerates more axial force with less follicle displacement. Loose skin results in significant displacement of skin and follicle in response to more axial force. Skin traction can help reduce skin movement in response to an axial force.

S. Follicle splay increases the risk of follicle transection and often requires a larger punch or a more shallow incision.

For each procedure I take into consideration three types of density: hair density, follicular unit density, and calculated density. Dividing the hair density by the follicular unit density gives the calculated density.[4,5] Those individuals who have a calculated density (as defined in the standard FUE terminology) greater than 3.0 hairs per follicular unit are excellent candidates for sub-follicular unit harvesting (SFUH). In SFUH, I remove 1-4 (most commonly 2) follicles from a follicular cluster using a smaller punch. In such donor areas, I often can obtain a much higher graft count by harvesting from adjacent follicular clusters rather than by harvesting from every other intact follicular unit. With sub-follicular unit harvesting, you have the potential to produce a better aesthetic donor area and more grafts. It is important to remember that 7,000-9,000 grafts obtained by sub-follicular unit harvesting may be the equivalent of only 5,000 full-size grafts with respect to the total number of hairs transferred.

The anatomical location influences the size of follicular units and the hair diameter. The size of follicular units (number of hairs) tends to be larger medially and superiorly in the donor area. Hair diameter tends to be finer laterally and inferiorly in the donor area. This can influence your choice of punch size. You might want a smaller punch laterally where hair is finer and the follicular units contain fewer hairs, or you might want a larger punch superiorly where there tends to be more hairs per unit and hair that is coarser.

Learning Curve

The learning curve for the non-shaven approach is more difficult than for the completely or partially shaven approaches. In the shaven approach, you are dealing with proper punch positioning, following the direction of hair growth, and contending with blood flow. In the non-shaven approach, the complexity of dealing with long hair is added. When I first began the non-shaven approach, I would end each day with eye fatigue and headache. As I practiced the approach more, I learned to focus on the individual cut follicular clusters and not allow the untrimmed hair along with blood flow to distract me.

Both Drs. Bang and Park note that the rate of harvesting is slower with the non-shaven approach. Dr. Bang found that with continued practice the speed of extraction improved and the follicle transection rate decreased with the non-shaven approach. Dr. Bang prepares the donor area and manages donor harvesting in a similar fashion to my technique. With continued practice, most physicians find the rate of extraction and the quality of the grafts improves.

Donor Area Scarring and a Pre-look

Patients who have multiple scars or wide scars in their donor area present difficult challenges. If too much donor hair is removed in subsequent procedures, you risk revealing a scar that was previously concealed. In the past, before removing a strip, I always trimmed the area first, then let the hair fall back over the area. Next, I stepped back to look at the donor area without the long hair that I trimmed. If the scar was visible, I would reduce

the width of my strip in the area of the scar. In NSFUE, you have a wonderful opportunity to evaluate the appearance of scarring before harvesting. I never intend to overtrim the donor area, but after trimming, I always let the hair down and step back behind the patient to view the scar under normal lighting situations. If the scarring is apparent, I limit my extractions.

A non-shaven approach allows patients to view their donor area prior to harvesting to ensure acceptance of the removal of grafts. On occasion, FUE patients with a lower follicular unit density or fine hair have complained about being too thin in certain regions of the donor area even after a single pass of 2,000 grafts. The pre-look with NSFUE allows the patients an opportunity to voice their concerns prior to harvesting. On one occasion, I had a female who elected to cancel surgery after trimming her donor area for NSFUE because she felt the residual long hair was too thin. In this case, it was better to discover her displeasure prior to extracting the trimmed follicles.

Once the grafts are extracted from the donor area, they are managed the same regardless of extraction technique. If the recipient area is not shaved, recipient site preparation is more challenging. However, the non-shaven recipient area is managed the same way as with a non-shaven strip harvest: I attempt to place the grafts as quickly as possible following their extraction.

Complications

Individuals who undergo NSFUE wish to conceal their recent hair transplant procedure. When the donor area is overtrimmed, the patient may feel uncomfortable with his or her immediate post-surgical appearance. Provided that the physician does not overharvest, time should eliminate this concern. Donor area concealers can reduce patient anxiety while waiting for the trimmed hair to grow. If the donor area is overharvested such that scars become visible, the physician will need to add hair to the donor area to help conceal the scarring. Hair may be grafted into the scar, as well as to the periphery of the scar, and to donor extraction sites, as well as to thin donor areas between existing follicular groups. A custom wig can be crafted using the hair trimmed when preparing the donor area for NSFUE. This wig can be glued to the scar as a temporary measure to help conceal an overtrimmed donor area. Micropigmentation to hypopigmented extraction sites and to donor scars can also be considered.

Mechanical extractors typically apply a rotating or oscillating motion to the punch. When harvesting with a mechanical extractor, hair can be unintentionally plucked or cut by the rotating punch. Depth stops that externally rotate with the punch increase the probability that hair will catch and begin to accumulate on the rotating punch. Use of a non-rotating depth stop external to the rotating punch will help reduce the probability of this complication, but it will not eliminate the risk. Also, use of intermittent rotation or oscillation will help reduce the risk of long hair torsion and cutting with the punch. If hair accumulates on the punch, the punch must be stopped and the accumulated hair removed from the surface of the punch to avoid promoting additional hair accumulation.

When grafts are harvested in a dense fashion by FUE in narrow bands of shaved patches, clusters of hypopigmented scars result. This complication is often unacceptable to patients. To remedy, scalp hair or beard hair may be grafted into the hypopigmented scars. Scalp hair should be harvested in an irregular well-spread-out fashion from the safe donor area when treating this complication. This complication can also be treated with micropigmentation. Ultimately, it is better to avoid this complication by eliminating the shaved patch from your list of procedures.

Summary

Often, patients cannot shave their heads due to work or social obligations. Thus, I believe the NSFUE approach is the future of hair transplant surgery. Patients can resume their normal lives much more rapidly and patients with scars do not have to unmask their embarrassing scars. Graft counts can routinely be obtained in excess of 3,000, and on occasion in excess of 4,000, using a non-shaven approach. With practice, follicle transection rates with NSFUE are just as low as with the shaven approach to FUE. With NSFUE, donor area preparation time is longer, but the speed of extraction is rapid. You also can evaluate the donor area appearance prior to maximal harvesting, and adjust harvesting by getting a look into the future.

This procedure is state-of-the-art FUE and the future for hair restoration surgery. A video of the non-shaven FUE technique is available at http://gdriv.es/ns-fue.

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Editor's note: Dr. Cole is reluctant to give an ideal hair length for FUE, as is it impossible to measure. In my experience, it is somewhere between ½ and 1mm. I have found that there are some cases in which the shaven patches work well. The patient wants to do small treatments and gradually enlarge the transplanted area, so there is a planned course of sequential harvest and the end result will be an evenly dispersed harvest and a full restoration that is gradually realized. I do this only with patients who are clearly committed to a course of treatment with sessions about every 6 months. In these instances, I intentionally decrease my usual harvest density. Dr. Cole prefers a stand-alone solution that does not presume the patient will come back for more treatment. I see his point, but still maintain that I can recognize patients who will stick with this treatment approach and achieve a goal of an even donor harvest and bald area restoration. —RT◆